WiLink™ WLAN IP Real-Time Tuning Tool (RTTT)

This user's guide describes the TI RTTT software application that operates, tests, debugs, and calibrates the Wi-Fi® IP during development of WL127x, WL128x, and WL18xx TI wireless connectivity chipsets. This guide describes the RTTT modes of operation, connection and firmware download steps, and how to use the graphical user interface (GUI) to transmit, receive, and manipulate WLAN packets.

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1 Requirements

1.1 System Requirements

The RTTT requires the following hardware and software:

- PC running Pentium® II (minimum requirements)
- Operating systems: Windows® 2000, Windows XP, Windows 7
- Serial communication port (RS-232) or USB port with UART-to-USB adapter (to enable the RS232 interface on the WiLink 8.0 IC, see the *WL18xx Hardware Integration Users Guide* [SWRU437])
- For WLAN TX validation, standard RF equipment (such as a power meter, spectrum analyzer, vector signal analyzer, or a combined tester such as Litepoint™ IQxel™) for TX output power, WLAN mask, and EVM measurements.
- For WLAN RX validation, a vector signal generator to generate WLAN packets for the IC to analyze.

Debug and calibration tools for WLAN and *Bluetooth*® require four UART ports. The most efficient way to drive these ports to the PC is to use a UART-to-USB converter (not included in the wireless tools package). TI recommends using the WL18XXCOM82SDMMC adapter with the TI WL1837MODCOM8I module or WL1835MODCOM8B module on the COM8 board.

NOTE: Multiple UART-to-USB adapters are available on the market, such as the FTDI Chip™ development modules.

1.2 Configuration Requirements

The RTTT application for the WiLink 8 WLAN NLCP package release requires the latest versions of the following configuration files:

- WiLink 8 WLAN firmware
- WiLink 8 WLAN .ini files
- WL128x firmware:
  - wl128x-fw-4-mr.bin
  - wl128x-fw-4-sr.bin
  - wl128x-fw-4-plt.bin
  - WL128x INI files
- WL127x firmware:
  - wl127x-fw-4-mr.bin
  - wl127x-fw-4-sr.bin
  - wl127x-fw-4-plt.bin
  - WL127x INI files

The installation files are located in the directory named *Wireless Tools* at the installation path configured during installation. By default, the files are located at the following path:

C:\Program Files (x86)\Texas Instruments\Wireless Tools

NOTE: Throughout this document, the directory in which the installation files reside is referred to as the *Installation directory*.

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2 Installation

The RTTT application is part of the TI wireless tools package release. When the wireless tools package is installed, the RTTT icon is created in the Texas Instrument\Wireless Tools folder at Start→Programs and on the desktop (see Figure 1).

Figure 1. RTTT Icon

To start the RTTT application, double-click the RTTT icon. The software initializes and displays the RT^3 main working window (see Figure 2).

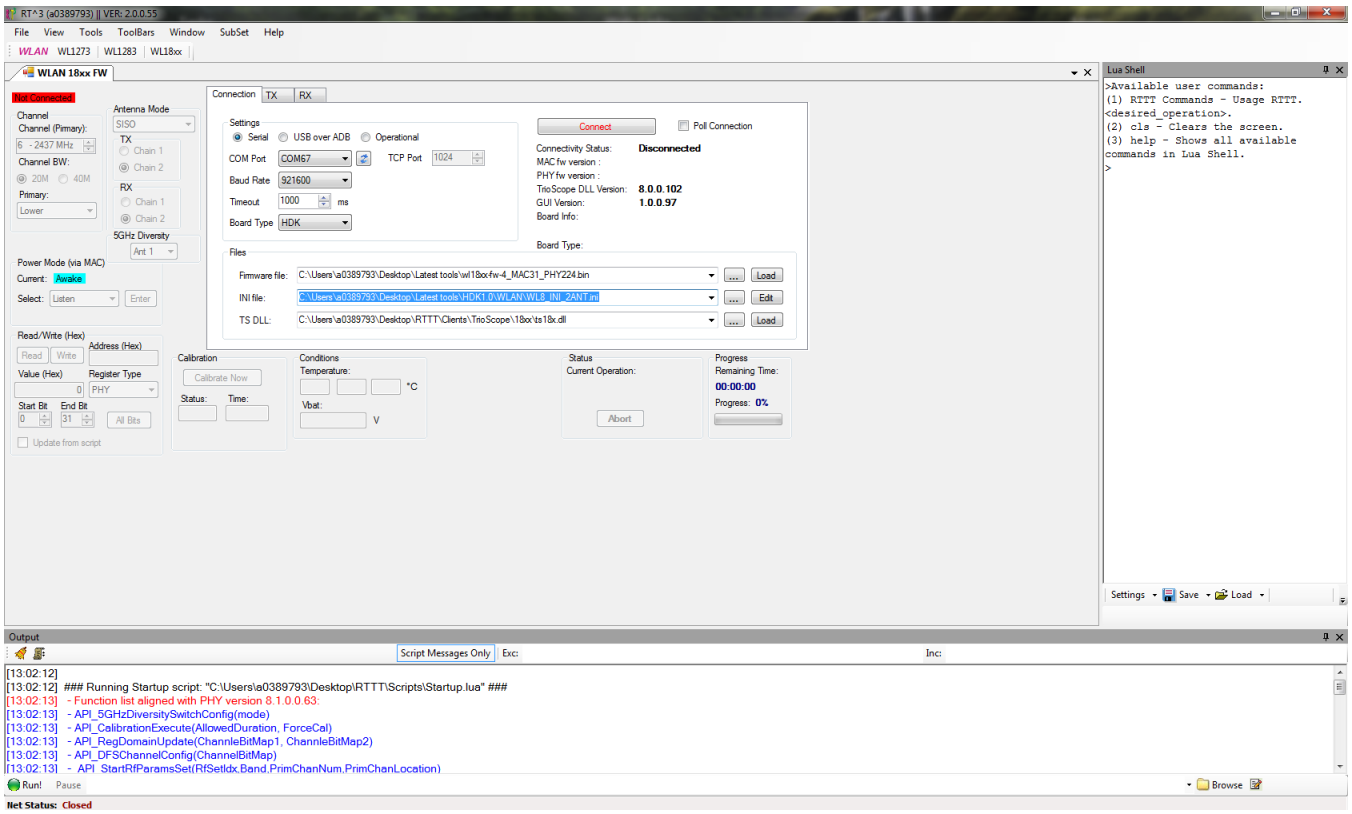

Figure 2. RT^3 Main Working Window

3 Modes of Operation

The RTTT includes the following modes of operation:

- Serial port
- USB over Android® debug bridge (ADB)
- Operational mode

The modes are selected in the Settings area on the Connection tab of the main working window.

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3.1 Serial Port Mode

The serial port mode provides a direct PC connection of the WLAN IP through the RS-232 interface, typically using a UART-to-USB bridge. This mode allows firmware download and full operation of the Wi-Fi IP in TX and RX modes. The serial port mode is also the default debug option on the Windows platform used to operate the device in Wi-Fi TX and RX mode, carrier wave (CW), and using the read/write registers.

Figure 3 shows the Settings area with Serial port mode selected.

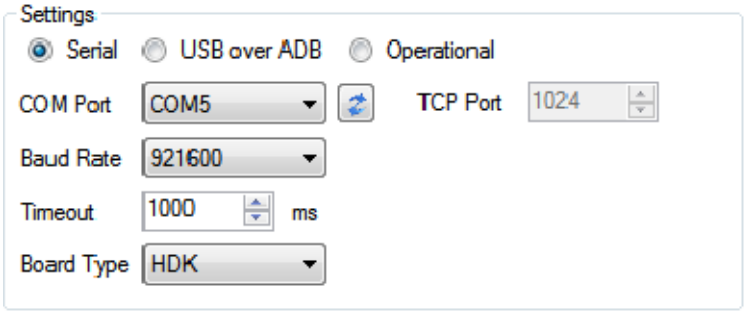

Figure 3. Settings Area With Serial Port Selected

3.2 USB Over Android Debug Bridge (ADB) Mode

The USB over ADB mode provides a connection to the IC through the ADB on Android systems. This mode allows read and write of internal IC registers and firmware globals after the firmware is downloaded by the host processor.

To enter the USB over ADB mode using the WLAN SDIO interface in a processor shell window terminal, perform the following steps at the command prompt:

1. Type *adb root* and press Enter.
2. Type *adb remount* and press Enter.
3. Type *adb shell* and press Enter.

To enable the bridge, in the adb shell enter:

asi /sys/kernel/debug/ieee80211/phy/wlcore/mem &*

The following message displays, identifying the adb device:

```
root@sdisl:/ # * daemon not running. starting it now on port 5038 *
* daemon started successfully *
List of services attached
command failed: Device or resource busy (-16)
```

Figure 4 shows the Settings area with USB over ADB mode selected and read and write registers.

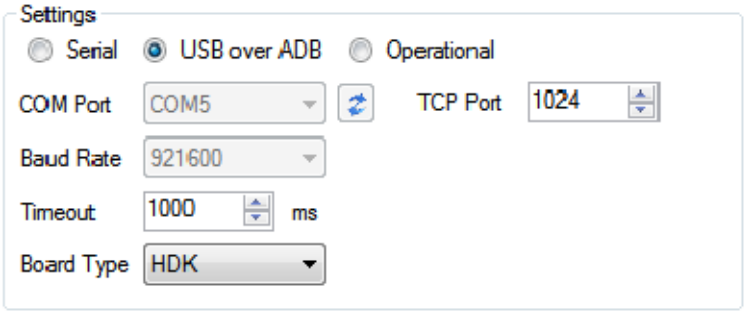

Figure 4. Settings Area With USB Over ADB Mode Selected

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3.3 Operational Mode

On Linux® platforms, the WLAN firmware is downloaded by the SDIO driver to the WiLink 8 device while in operational mode. RTTT operational mode provides a debug connection to the IC using the dedicated RS-232 interface to the read and write registers.

To enable debug capabilities, such as writing and reading registers and firmware globals, use the RTTT operational mode.

Figure 5 shows the Settings area with Operational mode selected.

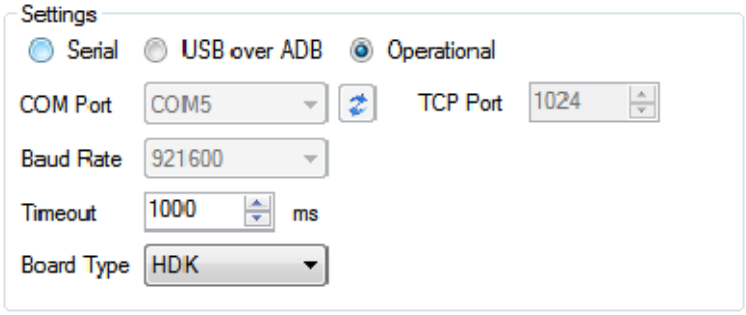

Figure 5. Settings Area With Operational Mode Selected

4 Connection and Firmware Download

The Connection tab connects the application to a target system-on-chip (SoC) and includes the connection group, which sets the correct port from the available host-PC serial ports as well as the appropriate baud rate (see Figure 6).

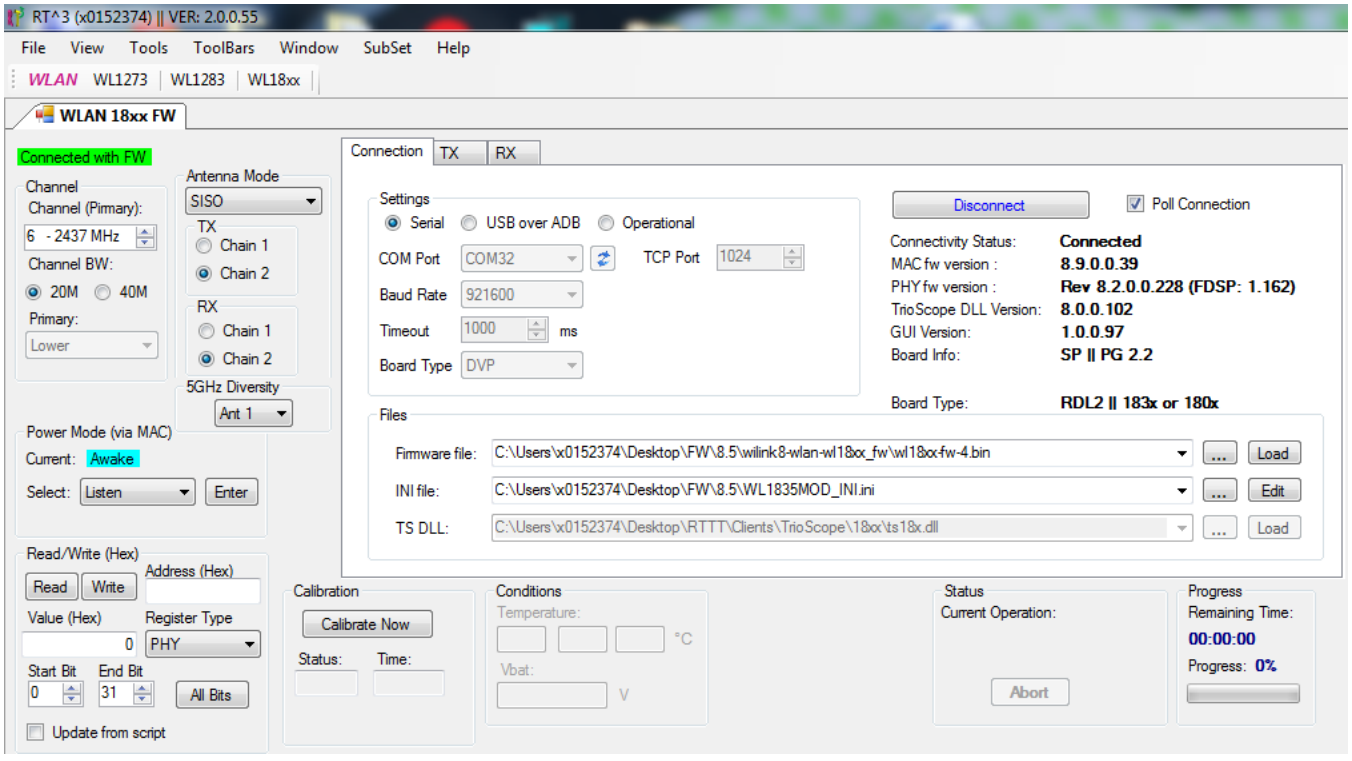

Figure 6. RT^3 Main Working Window After Connection and Firmware Download

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To connect the RTTT application to the SoC, perform the following steps:

1. In the Settings area of the Connection tab, set the COM port and baud rate fields.

NOTE: The default baud rate is 921600 but can be updated to 3M.

2. In the Files area of the Connection tab, set the firmware and INI file from the git folder.
   (a) Click the firmware and INI file path and browse to the location of the file, as shown in Figure 7.

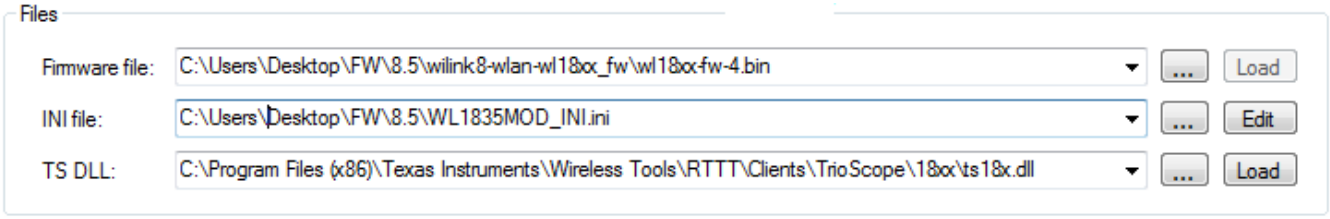

Figure 7. Selecting the Firmware Files to Download

   (b) Click Load. The RTTT application begins downloading the firmware files entered in the previous steps (see Figure 8).

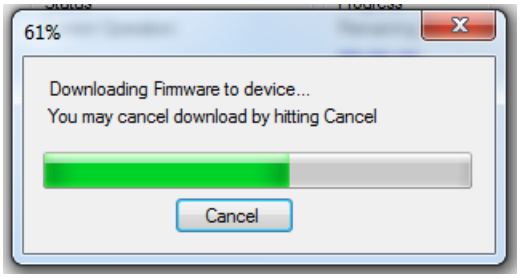

Figure 8. Downloading Firmware Message

3. To select a channel, in the Channel area select the channel number/frequency from the Channel (Primary) list box.
4. To select the channel bandwidth, in the Channel area, click the 20M or 40M button. If the Channel BW is set to 40 MHz, the Primary list box becomes active. Select Upper or Lower channel. Figure 9 shows the packet types for Channel 7.

NOTE: Upper and lower selection is with respect to the primary channel.

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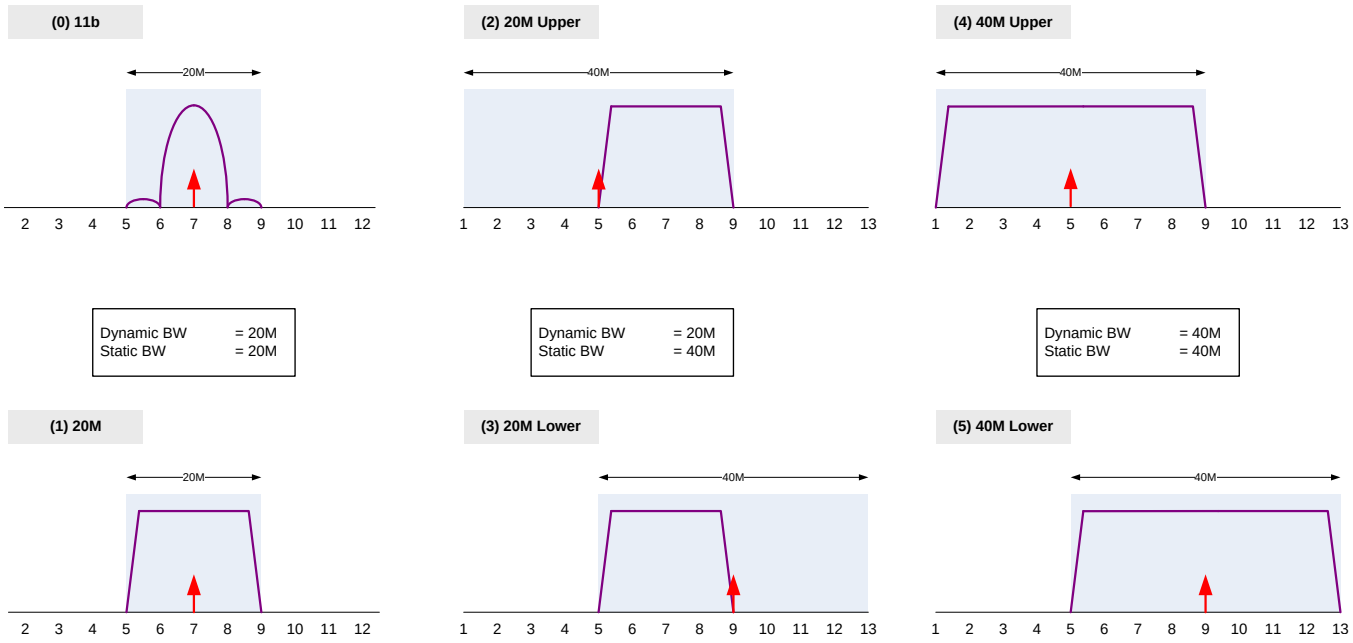

Figure 9. Packet Types for Channel 7

4.1 Register Reads and Writes

Figure 10 shows the Read/Write [Hex] area, used to select read and write registers.

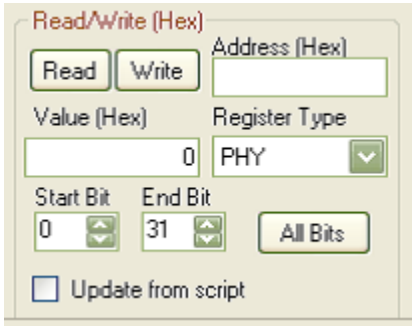

Figure 10. Read and Write Registers

4.2 Power Mode Menu

Figure 11 shows the Power Mode (via MAC) area, which contains the Select menu for the WLAN SoC. The Select menu lists the following power mode options:

- Awake mode (default)
- Listen mode
- Energy low power (ELP) mode

NOTE: TX can be set in awake mode only (for more information on TX, see Section 5, *TX Tab*).

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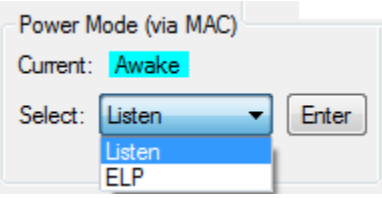

Figure 11. Power Mode Menu

4.2.1 Awake Mode

In awake mode, MAC, PHY, and DRPw are fully active, and various RTTT functions are all active.

4.2.2 Listen Mode

In listen mode, MAC and PHY are awake on Beacon profile mode.

4.2.3 ELP Mode

In ELP mode, MAC, PHY, and DRPw are in shutdown mode. The WiLink SoC cannot receive or transmit packets.

To exit ELP mode, click the Exit ELP pop-up window that appears on mode entry.

While in ELP mode, the WiLink WLAN IP operates on slow clock only.

4.3 Antenna Mode Menu

Figure 12 shows the Antenna Mode area, used to select the antenna mode. MIMO and SISO antenna configurations are available at the 20-MHz bandwidth.

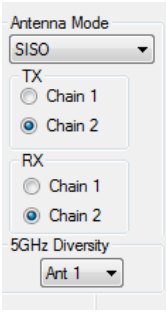

Figure 12. Antenna Mode Area of the RT^3 Window

4.3.1 Supported Antenna Configuration

Table 1 describes the supported antenna mode configurations.

Table 1. Antenna Mode Supported Configuration

Antenna Mode	TX		RX	
	Chain 1	Chain 2	Chain 1	Chain 2
5-GHz SISO	X	A Band	X	A Band
2.4-GHz SISO	X	BG2	X	BG2
2.4-GHz MIMO	BG1 + BG2	BG1 + BG2	BG1 + BG2	BG1 + BG2

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RF_ANT1 is the main antenna for 2.4-GHz SISO and the default antenna for the 5 GHz on the WL1837 and WL1807 modules.

RF_ANT2 is a MIMO-only (MCS8 to MCS15) secondary antenna for 2.4-GHz MIMO operation and can be a diversity antenna for the 5 GHz on the WL1837 and WL1807 modules.

Figure 13 shows an example of the antenna connection that covers all antenna mode configurations.

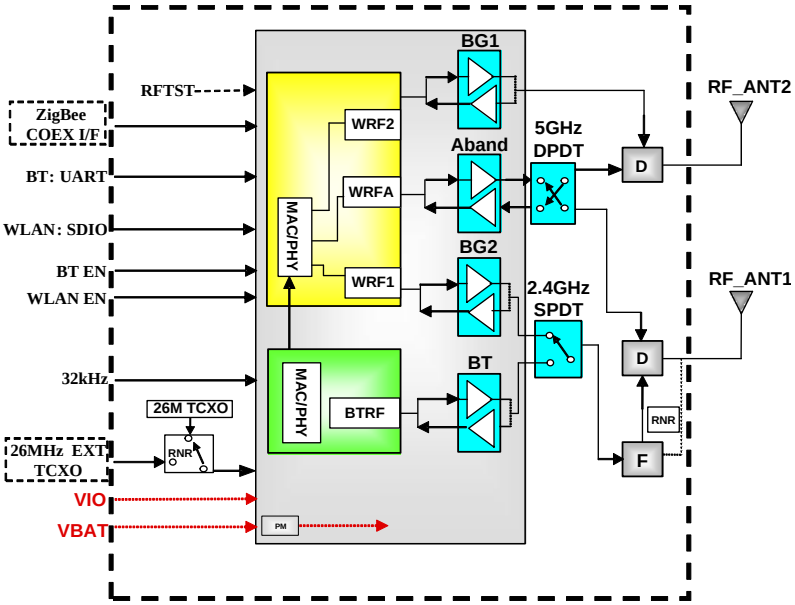

Figure 13. TI Module WL1837 Block Diagram

4.3.2 5-GHz Diversity (WL1837MOD and WL1807MOD Only)

Antenna selection is controlled by the WLAN IP internal antenna diversity algorithm, based on the link quality of each antenna.

To test the mechanism:

1. After downloading the firmware, set the 5-GHz channel.
2. In the Antenna Mode area of the main working window, select Ant 1 or Ant 2 (see Figure 12) from the 5GHz Diversity drop-down menu.
3. Perform a channel tune calibration by setting the same channel number or selecting the 20M or 40M Channel BW button.

For example:

1. Select channel 5200 MHz.
2. Select Ant1 in the 5-GHz Diversity area.
3. Select channel 5200 MHz.

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5 TX Tab

Figure 14 shows the WLAN 18xx FW TX tab.

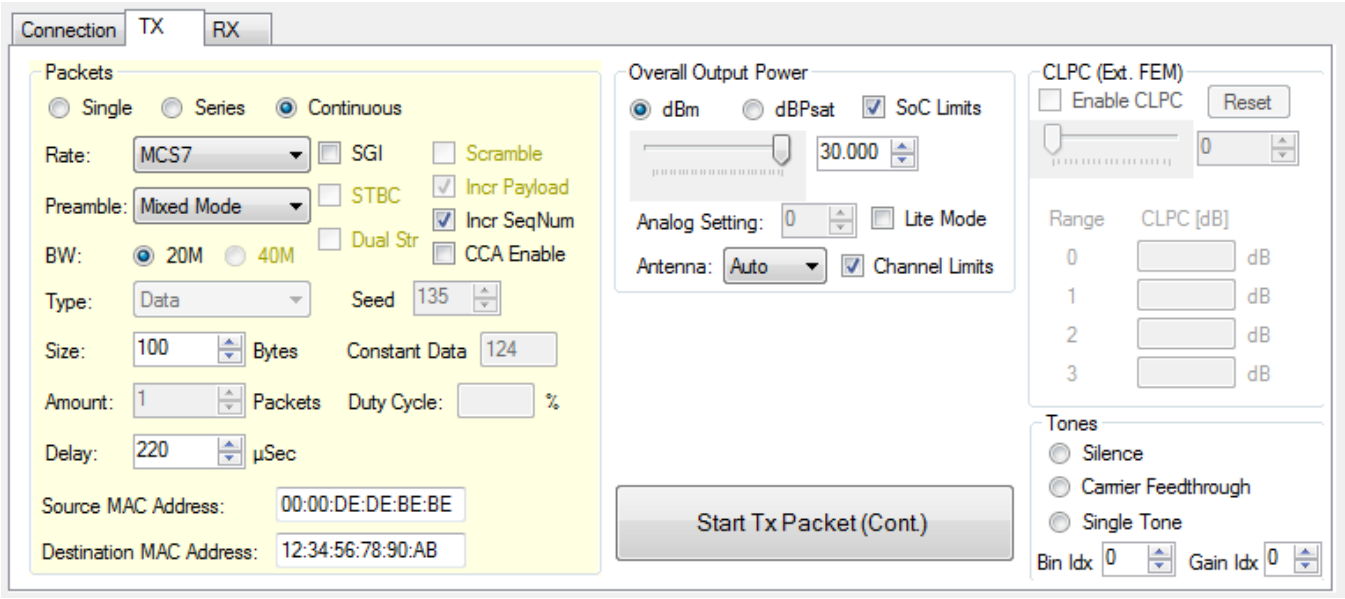

Figure 14. TX Tab Display

5.1 TX Packets Section

Table 2 describes the TX parameters.

Table 2. TX Parameters

Parameter	Description
Mode	Single/Series: The number of packets to broadcast is set by the Amount parameter.
	Continuous: Packets are broadcast continuously while transmission is ongoing (Start TX packet is pressed).
Rate	802.11b: 1M and 2M DSSS, 5.5 and 11M CCK
	802.11a/g: 6M, 9M, 12M, 18M, 24M, 36M, 48M, 54M OFDM
	802.11n: MCS0-15
Type	Not used
Size	Minimum: 24 bytes
	Maximum: 4065 bytes
Amount	Available values: 1 to 10,000 packets
Delay	Delay between packets:
	Minimum: 220 µs
	Maximum: 1000000 µs
Preamble	Short/long: (802.11b rates, except 1M DSSS – only long Preamble allowed)
	OFDM (802.11a/g rates)
	Mixed-mode/Greenfield (802.11n rates)
SGI	SGI: Short guard interval (only for 11n)
	Checked: Short guard interval
	Unchecked: Long guard interval
Source/Destination MAC Address	Set as 6 bytes in format: xx:xx:xx:xx:xx:xx

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5.2 TX Tab Overall Output Power Area

The Overall Output Power area of the WLAN 18xx FW TX tab controls output power using a slider or a menu, allowing the desired power level to be set manually in dBm. To deliver maximum power to the antenna, select 30.000 dBm power and check the SoC Limits box.

To pass regulatory certification, additional power limitations are required on specific channels. To enable the limitations specified by the .INI file, click the Channel Limits box (for more information on power limits, see the *WL18xx INI File User Guide*.

Figure 15 shows the Overall Output Power area.

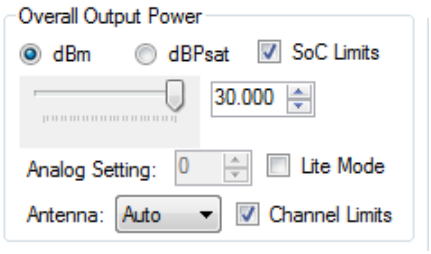

Figure 15. Overall Output Power Area

NOTE: Analog Setting, Antenna, dBPsat, and Lite Mode are for internal TI use only.

5.3 TX Tab Tones Area

Figure 16 shows the Tones area of the TX tab.

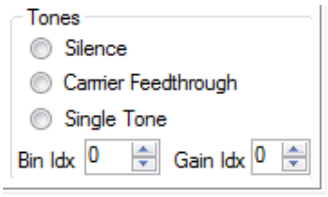

Figure 16. TX Tones Area

To create and transmit the CW of a signal, select one of the following tone options and then click the Start TX Packet (Cont.) button on the TX tab:

- Silence: TX chain is ON and operational, but no signal is transmitted.
- Carrier Feedthrough: TX chain is ON and operational, and the LO is transmitted.
- Single Tone: TX chain is ON and operational, and a sinusoidal signal is transmitted with the following configuration options
  - Analog gain step
  - Offset from the carrier frequency (in OFDM bins)

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5.4 TX Duty Cycle Configuration

Figure 17 shows the Type, Size, Amount, and Delay options (highlighted in red) used to set the duty cycle in the Packets area of the TX tab.

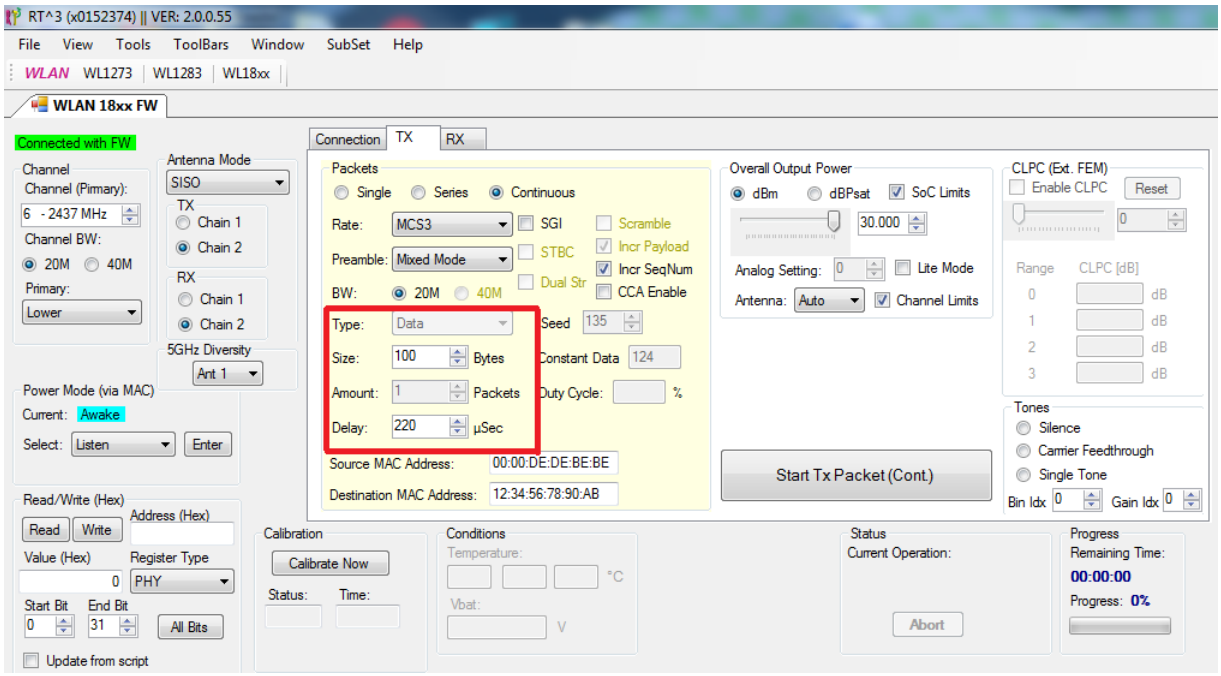

Figure 17. Duty Cycle Control

For best TX performance, TI recommends setting the duty cycle of the device to less than 40% by selecting the correct packet length and delay time for a specific rate.

$$D.C\,[\%] = \frac{TxTime}{TxTime + Delay[\mu s]} = \frac{\frac{8 \times Size[Bytes]}{DataRate\left[\frac{bits}{s}\right]}}{\frac{8 \times Size\,[Bytes]}{DataRate\left[\frac{bits}{s}\right]} + Delay[\mu s]} \quad (1)$$

Based on Equation 1, Table 3 and Table 4 list calculated values for 30% DC at the most common rates.

Table 3. 20-MHz BW Rates

Rate	20-MHz BW	
	Size (Bytes)	Delay (µs)
1DSSS	26	938
11CCK	143	700
54OFDM	1539	583

Table 4. 20-MHz and 40-MHz BW Rates

Rate	20-MHz BW		40-MHz BW	
	Size (Bytes)	Delay (µs)	Size (Bytes)	Delay (µs)
MCS0	218	705	429	700
MCS7	1528	467	1365	280
MCS15	1495	303	—	—

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5.5 Output Power Test on the WiLink 8 Device

The WiLink 8 device has an integrated power amplifier for the WLAN IP. The WiLink 8 device is characterized over PVT (process, voltage, temperature) to provide the maximum possible power to the antenna, while keeping the respective limits of the IEEE mask and EVM requirements.

Operational mode includes two possible output power levels:

- Maximum output power
- 8-dBm power (this mode is only set on the highest rate of the specific rate group 11b, 11g, or 11n), when the link is optimized for power consumption optimization.

The maximum output power is controlled by the device firmware. When setting the RTTT to maximum power in the slider, the power is automatically clipped to the maximum possible value that complies with IEEE requirement without user interference.

5.5.1 TX Testing Procedure

To test the output power on the WiLink 8 device, perform the following steps (see Figure 18):

1. In the Overall Output Power area, select dBm mode.
2. Click the SoC Limits box to enable the SoC limits option.
3. Using the slider, select a power setting of 30 dBm (see Figure 18).
4. In the Packets area, select the appropriate values from the Rate, Size, and Delay menus.
5. In the Channel area, set the channel to perform full RF calibration before TX.
6. To transmit, click the Start TX Packet (Cont.) button.

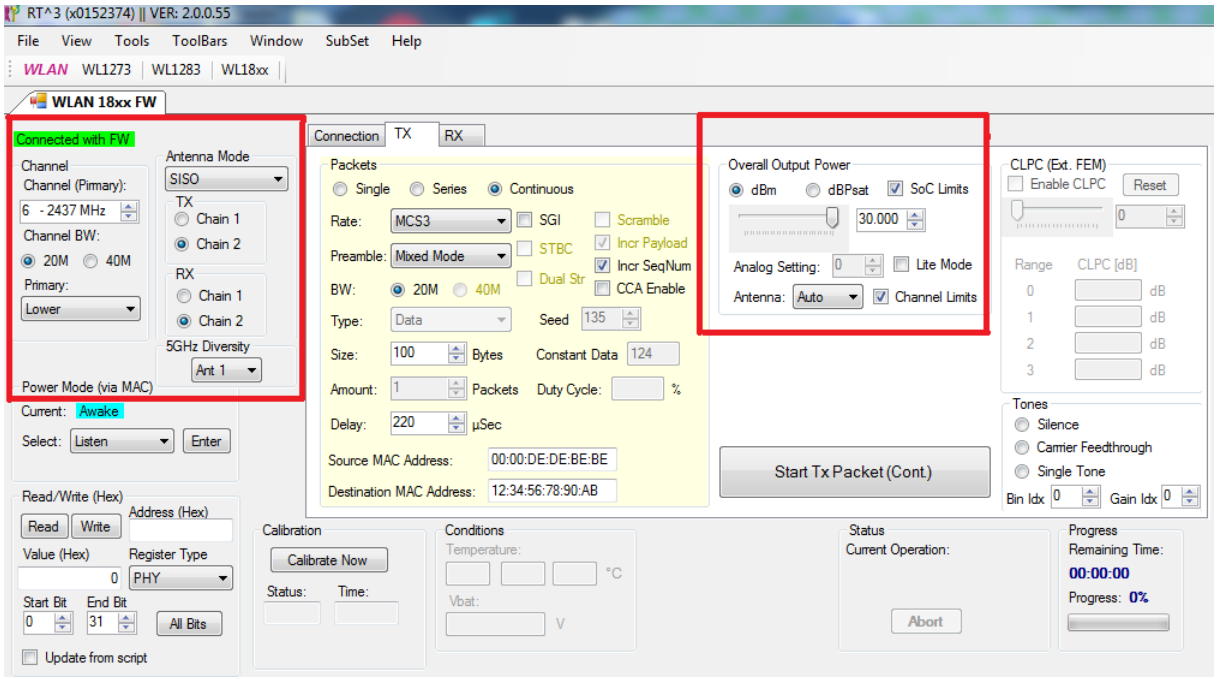

Figure 18. WLAN 18xx FW Tab

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6 RX Tab

Figure 19 shows the RX tab.

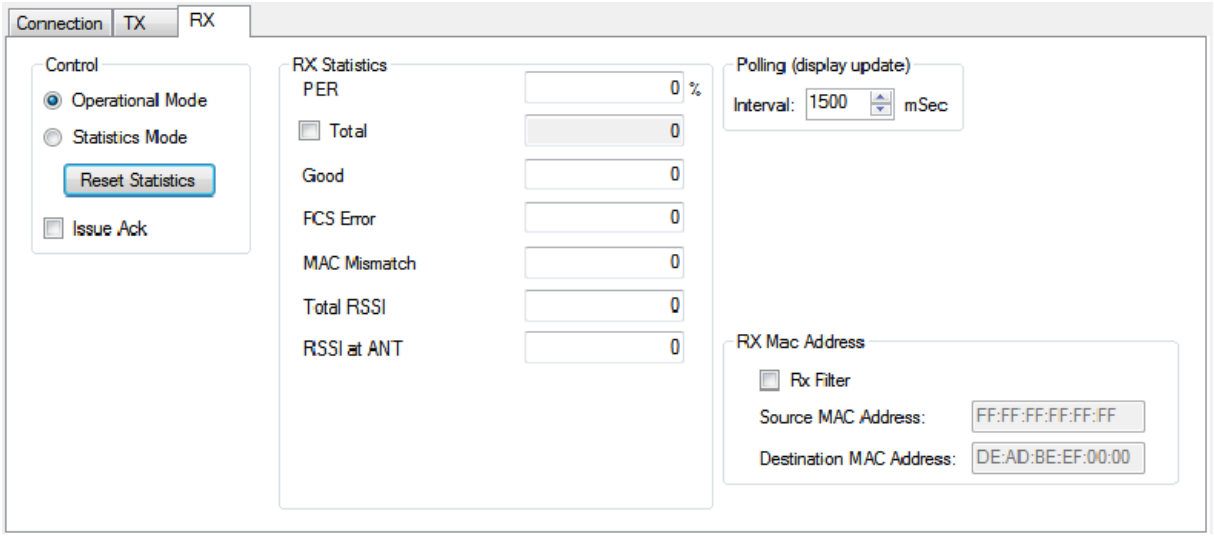

Figure 19. RX Tab

6.1 RX Statistics Area

The RX Statistics area displays the results of the received packet counters and the quantities of the packet types (good, FCS error, MAC mismatch) received since the last statistics reset as follows:

- Packet error rate (PER): Calculated by dividing the amount of error packets by the amount of total packets
- Total: If the Total box is unchecked, the total number of packets received by the WLAN firmware is displayed; if the Total box is checked, the user can enter the number of expected packets.

  For example, if an external packet generator is set to transmit 1000 packets, enter the same number (1000) in this box. This value is used by the RTTT application to compute PER.
- Good: Displays the number of good packets received since the last statistics reset
- FCS error: Displays the number of FCS error packets received since the last statistics reset
- MAC mismatch: Displays the number of packets with a destination address mismatch that are then configured by the filter

If the Rx filter box in the RX Mac Address area is checked, the Rx MAC Address filter is enabled to drop all packets with different MAC addresses than configured. Using FF:FF:FF:FF:FF:FF is equivalent to filter disabled.

6.2 Sensitivity Measurements

Sensitivity is measured by configuring the device to RX statistics mode, transmitting the data from ESG, and collecting the statistics from the device.

The sensitivity can be calculated using the statistics from the device (number of transmitted packets, number of received packets, and the number of good packets).

The default mode of the device is Operational mode, in which the device receives packets but does not gather statistics.

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6.2.1 Sensitivity Testing Procedure

To measure sensitivity, perform the following steps:

1. In the Control area of the WLAN 18xx FW RX tab, configure the device to Operational Mode.
2. In the Channel area, select the channel.
3. In the Control area of the WLAN 18xx FW RX tab, configure the device to Statistics Mode.
4. To clear the statistics from the device, click the Reset Statistics button.
5. Transmit the packets burst from the ESG.
6. Read the results (statistics) from the device.

Figure 20 shows the WLAN 18xx FW RX tab.

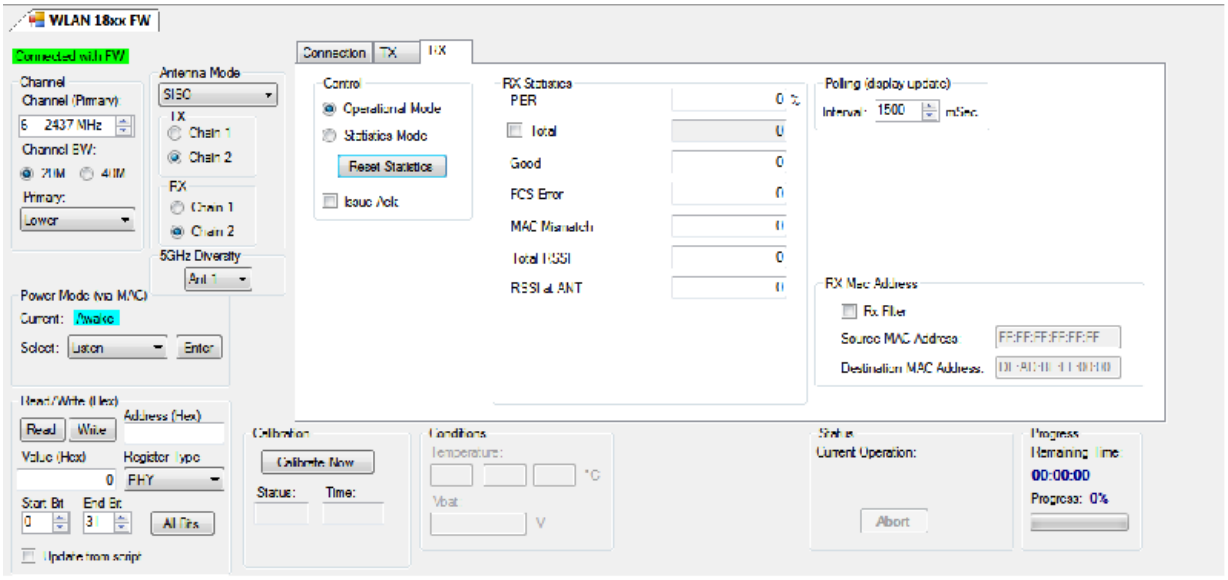

Figure 20. RX GUI

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Terms and Abbreviations

Table 5 lists terms and abbreviations.

Table 5. Terms and Abbreviations

Term	Description
ADB	Android debug bridge
BD_ADDR	*Bluetooth* device address
BER	Bit error rate
BT	*Bluetooth*
BW	Bandwidth
CW	Carrier wave
DRPw	Digital radio processor (wideband)
ELP	Energy low power
FCS	Frame check sequence
HCI	Host controller interface
Host/host PC	A PC connected to the device through the serial port
LMP	Link manager protocol
LQM	Link quality monitor
MAC	Medium access control
MCU	Microcontroller unit
MIMO	Multiple input, multiple output
OSI	Open Systems Interconnection model
PER	Packet error rate
PHY	Physical layer of the OSI model
PVT	Process, voltage, temperature
RF	Radio frequency
RSSI	Received signal strength indication
RTTT	WLAN Real-Time Tuning Tool
SDIO	Secure digital input output
SGI	Short guard interval
SISO	Single input, single output
SW	Software
SoC	System-on-chip
VS	Vendor-specific

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Revision History

Changes from D Revision (January 2014) to E Revision **Page**

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